Sub A1

Claims

1. A method for laser machining a depthwise self-limiting blind via in a multilayered target including at least first and second conductor layers having respective first and second conductor ablation energy thresholds and a dielectric layer having surfaces and a dielectric ablation energy threshold, the first and second conductor layers positioned above and below, respectively, the surfaces of the dielectric layer and the first and second conductor ablation energy thresholds exceeding the dielectric ablation energy threshold, comprising:

generating a first laser output containing at least one laser pulse having a first energy density over a first spatial spot size, the first energy density being greater than the first conductor ablation energy threshold;

applying the first laser output to the target to remove the first conductor layer within a first spot area of the target;

generating a second laser output containing at least one laser pulse having a second energy density over a second spatial spot size, the second energy density being less than the first and second conductor ablation energy thresholds and greater than the dielectric ablation energy threshold; and

applying the second laser output to the target to remove the dielectric layer within a second spot area of the target and, as a consequence of the second energy density being less than the second conductor ablation energy threshold, to leave the second conductor layer substantially unvaporized and thereby form a depthwise self-limiting blind via.

2. The method of claim 1 in which the dielectric layer comprises benzocyclobutane (BCB), bismaleimide triazine (BT), cardboard, cyanate esters, epoxies, paper, phenolics, polyimides, PTFE, or

combinations thereof and the metal layer comprises aluminum, copper, gold, molybdenum, nickel, palladium, platinum, silver, titanium, tungsten, or combinations thereof.

3. The method of claim 1 in which the laser pulses comprise a wavelength within a range of about 100-400 nm.

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4. The method of claim 3 in which the laser pulses have a temporal pulse width shorter than about 100 ns, the first laser output has an average output power of greater than about 100 mW measured over the spatial spot size, and the laser pulses are generated at a repetition rate of greater than about 1 kHz.

5. The method of claim 1 in which the first and second laser outputs have respective first and second output powers, and the first output power is greater than the second output power.

6. The method of claim 5 in which the first and second spatial spot sizes are the same.

8 ~~7~~. The method of claim 1 in which the first spatial spot size is smaller than the second spatial spot size.

9 ~~8~~. The method of claim 8 ~~7~~ in which the first and second laser outputs have respective first and second output powers that are substantially the same.

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9. The method of claim 3 in which the first spatial spot size is less than about 100 μm across its surface diameter.

Sub B3

10. The method of claim 3 in which the laser output is generated by a solid-state laser comprising Nd:YAG, Nd:YLF, Nd:YAP, or Nd:YVO_4.

11. The method of claim 1 in which the spatial spot size defines a spot area that is smaller than and lies within a spatial region of the target, the spatial region having a periphery and a central portion, the method further comprising:

directing the laser pulses sequentially to multiple positions associated with the spatial region to remove multiple amounts of target material corresponding to the spot areas the multiple positions defining a contiguous set of spot areas extending outwardly from the central portion along a path to the periphery of the spatial region to remove the target material from the spatial region and thereby produce a blind via in the target material.

12. The method of claim 3 in which the dielectric layer includes a reinforcement material that comprises glass, aramid fibers, ceramics, or combinations thereof.

14 ~~13~~. The method of claim 1 in which the target comprises a circuit board.

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14. The method of claim 1 further comprising:

positioning the target at a first distance relative to a focal plane prior to applying the first laser output; and

positioning the target at a second distance, different from the first distance, relative to the focal plane prior to applying the second laser output, thereby modifying the spatial spot size between the first and second laser outputs.

15. The method of claim 1 further comprising employing variable apertures, adjustable collimators or variable lens elements to modify the spatial spot size between the first and second laser outputs.

16. The method of claim 1 in which the conductor and dielectric layers form a first set of layers and the target comprises at least a second set of layers, including a second conductor layer and a second dielectric layer, the method further comprising:

repeating the steps of generating and applying first and second laser outputs to form a via through the first and second conductor and dielectric layers.

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17. The method of claim 16 in which the via is stepped between the first and second sets of layers.

18. The method of claim 1 in which the laser outputs create a noncircular via.

19. The method of claim 3 in which the laser output is generated by a solid-state laser comprising Nd:YAG, Nd:YLF, Nd:YAP, or Nd:YVO_4.

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20. The method of claim 5 further comprising changing the output power between the first and second laser outputs by employing a Q-switch, a polarization state changer, a quarter wave plate, or a Pockel's cell or by changing the output of a lamp or diode pump source.

Add A6

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